NACA

RESEARCH MEMORANDUM

LOW-SPEED STATIC LONGITUDINAL STABILITY AND CONTROL CHARACTERISTICS OF 60° TRIANGULAR-WING AND MODIFIED 60° TRIANGULAR-WING MODELS HAVING HALF-DELTA AND HALF-DIAMOND TIP CONTROLS

By Jacob H. Lichtenstein and Byron M. Jaquet

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Langley Field, Va.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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SUMMARY

A low-speed investigation was conducted in the Langley stability tunnel to determine the static longitudinal stability and control characteristics of two wing-fuselage combinations equipped with wing-tip controls of half-diamond and half-delta plan form. One wing was basically a 60° triangular wing of aspect ratio 2.31; the other wing was formed by incorporating a sweptback trailing edge in the basic wing. The half-delta tip controls were 10 percent of the area of the basic equilateral-triangular plan form, and the half-diamond tip controls were 5 and 10 percent of the same area (control areas are the sum of right and left tip controls).

The results of the investigation show that the lift effectiveness at low lift coefficients of both the half-delta and half-diamond controls was lower on the modified wing than on the basic wing; however, the pitching-moment effectiveness was about the same on both wing configurations. Although there was little difference in the lift effectiveness at low lift coefficients between the half-delta and half-diamond controls of the same area on either the basic or modified wings, the pitching-moment effectiveness was greater for the half-delta than for the half-diamond control. The decrease in lift and pitching-moment effectiveness with an increase in lift coefficient was less marked for the modified-wing than for the basic-wing configurations and therefore higher control effectiveness was obtained near the stall for the modified-wing configurations than for the basic-wing configurations.

The results also showed that the half-delta control produced higher maximum trim-lift coefficients than the half-diamond control on either the basic or modified wing. Higher maximum-trim lift coefficients were

obtained with a particular control when mounted on the modified wing than when mounted on the basic wing but at the expense of static longitudinal stability.

The decrease in the ratio of trim lift-curve slope to wing lift-curve slope which occurred with an increase in static margin was greater on the basic wing than on the modified wing. The ratio of the lift-curve slopes was not affected by the changes in control shape or size considered in this investigation.

INTRODUCTION

Because wings of triangular plan form combine certain aerodynamic and structural characteristics which are advantageous for high-speed flight, an appreciable amount of experimental research has been conducted in order to investigate their aerodynamic characteristics over a wide speed range (for example, see references 1 to 3). The problem of providing adequate longitudinal control for triangular wings, however, has not been investigated extensively. Some investigations of trailing-edge flap controls have shown that this type of control generally has good control effectiveness at moderate speeds (references 4 and 5), but the inherently high hinge moments of this type of control and the possible loss of effectiveness at transonic speeds as indicated by rolling experiments (references 6 and 7) make its suitability somewhat uncertain at transonic and supersonic speeds.

The results of some free-flight rocket tests (references 7 and 8) have indicated that half-delta-wing tip controls provide reasonable lateral control effectiveness at high subsonic, transonic, and low supersonic speeds. This type of control also permits a wide choice of control-hinge location and, hence, provides opportunity for aerodynamic balance of hinge moments. The feasibility of using such controls to provide longitudinal trim and control through the speed range has not been established.

In order to provide a more complete understanding of the low-speed characteristics of tip controls, a research program is being conducted in the Langley stability tunnel. As part of this program, the effects of symmetrical deflection of tip controls on the rolling and longitudinal characteristics of a 60° triangular-wing model were investigated and reported in references 9 and 10, respectively. The lateral control characteristics of the same model are presented in reference 11. The present investigation is concerned with the static longitudinal stability and control effectiveness characteristics of a basic 60° triangular wing-fuselage combination and of a modified 60° triangular wing-fuselage combination

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with tip controls of half-delta and half-diamond plan form. The basic triangular wing had 60° sweepback of the leading edge and an aspect ratio of 2.31; the modified wing differed from the basic wing primarily by the incorporation of some sweepback of the trailing edge. The modifications were tested to determine the effect of a longer control moment arm and of moderate changes to the basic plan form.

Theoretical control effectiveness characteristics for tip controls are lacking; however, the theory for wings of arbitrary plan form presented in reference 12 is compared with the experimental results where applicable.

SYMBOLS

The data presented herein are in the form of standard NACA symbols and coefficients of forces and moments which are referred to the stability system of axes with the origin at the projection of the calculated quarter-chord point of the mean aerodynamic chord on the plane of symmetry. The positive direction of the forces, moments, and angular displacements is shown in figure 1. The coefficients and symbols used herein are defined as follows:

C_L lift coefficient $\left(\frac{\text{Lift}}{qS_W}\right)$

$C_{L_{max}}$ maximum lift coefficient

C_D drag coefficient $\left(\frac{\text{Drag}}{qS_W}\right)$

C_m pitching-moment coefficient $\left(\frac{\text{Pitching moment}}{qS_W\bar{c}}\right)$

A wing aspect ratio $\left({b_W}^2/S_W\right)$

b_W wing span perpendicular to the plane of symmetry, feet

S_W wing area, including control area, square feet

S_c control area, square feet

c local wing chord parallel to the plane of symmetry, feet

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$\bar{c}$ wing mean aerodynamic chord parallel to the plane of symmetry, feet $\left(\frac{2}{S_W}\int_0^{b_W/2} c^2\,dy\right)$

x distance rearward from leading edge of root chord to assumed center of gravity $(\bar{c}/4)$ parallel to the fuselage center line, feet

$x_{c.p.}$ distance from assumed center of gravity $(\bar{c}/4)$ to center of pressure of load due to control deflection parallel to the fuselage center line (negative when center of pressure is rearward of center of gravity), feet

$x_{H.L.}$ distance rearward from assumed center of gravity to control hinge line parallel to the fuselage center line, feet

y spanwise distance perpendicular to the plane of symmetry, feet

ρ density of air, slugs per cubic foot

V free-stream velocity, feet per second

q dynamic pressure, pounds per square foot $\left(\frac{\rho V^2}{2}\right)$

α angle of attack of wing chord line in plane of symmetry, degrees

δ symmetrical deflection of left and right controls from wing-chord plane (positive when trailing edge is down), degrees

Λ angle of sweepback of wing leading edge, degrees

Λ_c angle of sweepback of control leading edge, degrees

$C_{L_\alpha} = \frac{\partial C_L}{\partial \alpha}$

$C_{L_\delta} = \frac{\partial C_L}{\partial \delta}$

$C_{m_{C_L}} = \frac{\partial C_m}{\partial C_L}$

$$C_{m_\delta} = \frac{\partial C_m}{\partial \delta}$$

Subscript:

t trim

APPARATUS, MODEL, AND TESTS

The present investigation was conducted in the 6- by 6-foot test section of the Langley stability tunnel with the model mounted on a single-strut support and pivoted about the quarter-chord point of the mean aerodynamic chord of the basic triangular wing. Forces and moments were measured by means of a six-component balance system.

The component parts of the model were constructed primarily of laminated mahogany and consisted of a triangular wing with the leading edge swept back 60° and a fuselage of circular cross section. Pertinent geometric characteristics of the basic-and modified-wing models are presented in figure 2 and table I. The basic triangular wing had an aspect ratio of 2.31 and modified NACA $65_{(06)}$-006.5 airfoil sections parallel to the plane of symmetry. The basic model was the same as that used in the investigations reported in references 9 to 11. For the present tests, however, the half-delta controls of 10 percent of the wing area (sum left and right control areas) on the basic wing were alternately replaced by half-diamond tip controls of 5.3 and 10 percent of the wing area. The plan form of the basic wing was also modified to include a sweptback trailing edge. As a result of the modification and fairing of the surface, the rearward part of the airfoil contour in the vicinity of the modification, changed from the original NACA $65_{(06)}$-006.5 section to a flat contour. The same half-diamond and half-delta tip controls were tested on the modified wing; however, the control areas were now only 4.4 and 8.5 percent of the wing area since the area of the wing was increased by the modification. Throughout the remainder of the paper the 4.4- and 5.3-percent area controls will be referred to as the small controls and the 8.5- and 10-percent-area controls as the large controls.

Photographs of the model as mounted in the tunnel are presented in figure 3.

The tests consisted of measurements of lift, drag, and pitching moment through an angle-of-attack range of -4° to 36° for control deflections of 10°, 0°, -10°, -20°, -30°, and -40° for each model configuration.

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In addition, a control deflection of -5° was used for the two half-diamond control surfaces on the modified triangular wing.

All tests were made at a dynamic pressure of 39.7 pounds per square foot. The test Mach number was 0.17 and the test Reynolds number ranged from about 2.00×10^{6} to 2.13×10^{6} depending on the mean aerodynamic chord for each configuration.

CORRECTIONS

Approximate jet-boundary corrections based on unswept-wing concepts were applied to the drag coefficient and angle of attack. The dynamic pressure and drag coefficient were corrected for the effects of blocking by the methods of reference 13. The data have not been corrected for the effects of the support-strut tares which, with the exception of the drag tare, are believed to be small.

RESULTS AND DISCUSSION

Presentation of Results

The basic data (variations of α, C_m and C_D with C_L for control deflections of 10° to -40°) are presented in figures 4 to 9. The variation of the lift and pitching-moment effectiveness parameters $\left(C_{L_{\delta}}\right.$ and $\left.C_{m_{\delta}}\right)$ through the lift-coefficient range are presented in figure 10. These parameters were determined from slopes of faired curves measured near $\delta = 0^{\circ}$ which generally were linear between $\delta = 10^{\circ}$ and $\delta = -20^{\circ}$. The effects of control area and plan form on the control effectiveness and control center of pressure, measured near zero lift and zero control deflection, are presented in figure 11. A comparison of experimental and theoretical lift effectiveness is presented in figure 12. The effects of varying the static margin on the available trim lift coefficient with various control deflections are shown in figure 13. The effects of static margin, control area, and plan form on the trim lift-curve slope ($\alpha = 0^{\circ}$, $\delta = 0^{\circ}$) are shown in figure 14.

Preliminary Remarks

The analysis of the present paper deals mainly with figures 10 to 14 and, therefore, only brief consideration is given to the basic data (figs. 4 to 9). Changing the control plan form from the large half-delta to the large half-diamond on either the basic- or modified wing-

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configurations had little effect on C_{L_α}, but decreased both $C_{L_{max}}$ and $C_{m_{C_L}}$ slightly as can be seen from table I. Reducing the area of the half-diamond control from 10 to 5.3 percent of the wing area appreciably reduced both C_{L_α} and $C_{m_{C_L}}$ and increased $C_{L_{max}}$ slightly (table I). The difference between the values of the parameters C_{L_α}, $C_{L_{max}}$, and $C_{m_{C_L}}$ obtained with a particular control surface on the basic-triangular-wing and the modified-triangular-wing configuration were generally small. The curves of C_m against C_L for the modified-wing configurations, particularly those with a moderate negative control deflection, in general, exhibit a decrease in static longitudinal stability at about $C_L = 0.5$; this decrease in stability appears only slightly for the basic-wing configuration (compare figs. 7 to 9 with figs. 4 to 6).

Since tares have not been applied to the drag-coefficient data, absolute values are not considered representative of free-air conditions. Incremental values (for example, the drag coefficient due to control deflection), however, should be reliable.

Inasmuch as comparisons of the control effectiveness between tip controls, such as tested herein, and trailing-edge flap controls were made in reference 10, no such comparisons will be included herein.

Effect of Control Area and Plan Form on Control Characteristics

Basic configuration.- The data in figure 10(a) show that changing from half-delta tip controls to half-diamond tip controls of equal area caused a slight reduction in the lift effectiveness C_{L_δ} over most of the lift-coefficient range. The values of C_{L_δ} for both 10-percent-area controls, however, decreased with an increase in C_L so that, at about $C_{L_{max}}$, the values of C_{L_δ} became negative. The small half-diamond tip controls had less than half the lift effectiveness of the large half-diamond controls at low lift coefficients. Although the lift effectiveness of the small control was greater in proportion to its area than the large control at high lift coefficients, its lift effectiveness also became negative at about $C_{L_{max}}$.

The pitching-moment effectiveness C_{m_δ} of the half-delta tip control was greater than that for the half-diamond controls of the same size. The value of C_{m_δ} for each of the large controls decreased with

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an increase in C_L so that, at $C_L = 1.0$, the control effectiveness was about half of that at $C_L = 0$ (fig. 10(a)). Although the small half-diamond control was less than half as effective as the large half-diamond control at low lift coefficients, its effectiveness throughout the lift-coefficient range was essentially constant and, hence, at moderate and high lift coefficients, it was more effective in proportion to its area than the large control.

The control effectiveness parameters (measured at $C_L = 0$) are presented as functions of the area ratio S_c/S_W in figure 11. The dashed curves shown in this figure are the same as the empirical curves presented in figure 10 of reference 10 for the half-delta tip controls on the basic wing. The data presented in figure 11 show that, although the values of $C_{L_\delta}/C_{L_\alpha}$ for the half-delta and half-diamond controls are about the same, the value of C_{m_δ} for the half-delta control is larger than for the half-diamond control. This results from the fact that the area of the half-delta control is concentrated farther rearward than the area of the half-diamond control and, consequently, the center of pressure is farther rearward.

A comparison of the $C_{L_\delta}/C_{L_\alpha}$ data with the values obtained from the theory of reference 12 for straight tapered wings is presented in figure 12 and shows that the experimental and theoretical values of $C_{L_\delta}/C_{L_\alpha}$ are generally in good agreement. The two points farthest from the line of perfect correlation are for the modified-wing configuration which differs considerably from a uniformly tapered-wing configuration and, consequently, the agreement is somewhat poorer.

The decrease in C_{m_δ} between the half-delta and half-diamond controls was greater for the small controls than for the large controls (fig. 11). This condition was due to the difference in design of the small and large controls. For the large controls, both the half-delta and half-diamond controls were hinged at the same location, and the center-of-pressure difference was due only to the difference in plan form. The small half-diamond control also was hinged at the same location as the large controls; whereas the small half-delta control was located and hinged farther rearward (as can be ascertained by comparing fig. 2 of this paper with fig. 2 of reference 10). The difference between the centers of pressure for the two smaller controls is, consequently, greater than for the two larger controls.

It is important to note that the comparison between half-delta and half-diamond controls is valid only when the control-to-wing-area ratio S_c/S_W is relatively small. If the half-diamond control area becomes relatively large, the basic general plan form is no longer that of a triangular wing.

The locations of the center of pressure $\left(x_{c.p.}/\bar{c}\right)$ of the load due to control deflection were computed from $C_{m_\delta}/C_{L_\delta}$ and are presented in figure 11. The data show the approximate magnitude of the change in center of pressure resulting from modification of the control plan form. It also indicates that the manner in which the half-diamond area was varied from 5.3 to 10 percent of the wing area, for the present tests, resulted in very little change in the control center of pressure, whereas a similar change in area for the half-delta controls resulted in about a $0.10\bar{c}$ change in center of pressure.

Modified configuration.- On the modified configuration (fig. 10(b)), the half-diamond tip controls had slightly greater lift effectiveness C_{L_δ} than the half-delta tip controls up to $C_L = 0.76$, whereas for the basic configuration the half delta had the greater lift effectiveness (fig. 10(a)). Above $C_L = 0.76$, the half-diamond controls became less effective than the half-delta controls. The values of C_{L_δ} obtained with a particular control, at low lift coefficients, were lower on the modified wing than on the basic wing. In contrast to its behavior for the basic wing, however, the values of C_{L_δ} for the modified wing were maintained, in general, throughout the lift-coefficient range and, consequently, near the stall the value of C_{L_δ} for a particular control was larger on the modified wing than on the basic wing.

The small decrease in relative control area to wing area S_c/S_W which occurred when the controls were changed from the basic to the modified wing would not be expected to produce the large decrease in $C_{L_\delta}/C_{L_\alpha}$ obtained for a particular control on the modified wing as compared to the $C_{L_\delta}/C_{L_\alpha}$ for the same control on the basic wing (fig. 11). This lower effectiveness may be attributed in part to the fact that the part of the load due to control deflection which carries over onto the wing affects a smaller area on the modified wing than on the basic wing (see fig. 2), and, consequently, the total load is somewhat smaller.

The half-delta control produced somewhat larger values of C_{m_δ} than the half-diamond control of the same area on the modified wing (fig. 10(b)) as on the basic wing. At low lift coefficients, the values of C_{m_δ} for a particular control were approximately the same on the modified wing as on the basic wing. The tendency of C_{m_δ} to decrease with increasing C_L, however, was not so great, and, as a result, the controls on the modified wing were more effective at high lift coefficients than on the basic wing.

The longer moment arm of the various control surfaces when mounted on the modified wing as compared to the controls mounted on the basic wing is probably responsible for the fact that the values of C_{m_δ} for a particular control were equal on either wing although the value of C_{L_δ} for the corresponding control was lower on the modified wing than on the basic wing (see fig. 2). The results presented in figure 11 indicate that the center of pressure for a particular control was approximately $0.20\bar{c}$ farther rearward on the modified wing than on the basic wing.

Effect of Control Area and Plan Form on Trim Characteristics

Basic configuration.- In addition to the data for the test static margin $\left(-C_{m_{C_L}}\right)$ which was different for each configuration (table I), the basic data (figs. 4 to 9) were used to calculate the trim lift coefficient available over the control deflection range for static margins of $0.08\bar{c}$ and $0.05\bar{c}$ for each model configuration where the test static margins were appreciably different from these values (fig. 13). The values of static margin used throughout this paper are values for the low lift-coefficient range.

As would be expected, the available C_{L_t} increased with an increase in control area and a decrease in static margin for the half-diamond controls as it did for the half-delta controls (reference 10). A comparison of figures 13(a) and 13(c) indicates that, for a given control deflection and static margin, the half-delta control produced somewhat higher values of maximum C_{L_t} than the half-diamond control. For example, at $0.05\bar{c}$ static margin, the half-delta control produced a maximum C_{L_t} of 0.75 $C_{L_{max}}$ (at $\delta = -25^\circ$), whereas the half-diamond control produced a maximum C_{L_t} of only 0.66 $C_{L_{max}}$ (at $\delta = -30^\circ$). The small half-diamond control produced a maximum C_{L_t} of about three-quarters of that produced by the large half-diamond control at a static margin of about $0.05\bar{c}$, whereas at a static margin of about $0.07\bar{c}$, it could produce only about one-half of the maximum C_{L_t} produced by the large control (value for $-C_{m_{C_L}} = 0.07$ for the larger control can be obtained by interpolation between the $-C_{m_{C_L}} = 0.05$ and $-C_{m_{C_L}} = 0.08$ curves).

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The curves presented in figure 14 show that the ratio $\left(C_{L_\alpha}\right)_t / C_{L_\alpha}$ decreased with an increase in static margin for all configurations and that the changes in the control shape or size considered in this investigation did not appreciably affect the value of $\left(C_{L_\alpha}\right)_t / C_{L_\alpha}$.

Modified configuration.- The effects of changes in the control size and plan form on C_{L_t} (figs. 13(d), 13(e), and 13(f)) were much the same on the modified wing as on the basic wing (for example, an increase in area and a decrease in static margin increased the available maximum C_{L_t} and also the half-delta control produced higher values of C_{L_t} than the half-diamond control). A particular control mounted on the modified wing, however, produced higher values of maximum C_{L_t} than the same control mounted on the basic wing. At low deflections, the change in C_{L_t} with δ was about the same for both basic and modified wing configurations; however, above deflections of -10° (for a static margin of $0.05\bar{c}$), the C_{L_t} increases very rapidly with δ until $C_{L_{max}}$ is attained. These same trends are exhibited for static margin of $0.08\bar{c}$, but to a lesser degree. Although a high maximum C_{L_t} is desirable, the high C_{L_t} obtained on the modified wing were obtained at the expense of static longitudinal stability. Although the static margin for these cases was $0.05\bar{c}$ at low values of C_L, the static stability was marginal or even unstable for some cases at high values of C_L (above 0.5). This decrease in stability results from the unstable breaks in the C_m against C_L curves mentioned previously.

From figure 14, it can be seen that the ratio $\left(C_{L_\alpha}\right)_t / C_{L_\alpha}$ decreased with an increase in static margin similar in manner to the behavior for the basic wing. The decrease, however, was less marked such that, at a static margin of $0.08\bar{c}$, the value of $\left(C_{L_\alpha}\right)_t / C_{L_\alpha}$ was about 5 percent higher on the modified wing than on the basic wing. The changes in control area and size considered in this investigation had no appreciable effect on the value of $\left(C_{L_\alpha}\right)_t / C_{L_\alpha}$ and, in this respect, is similar to the effect obtained on the basic wing.

CONCLUSIONS

An investigation made to determine the low-speed static longitudinal stability and control characteristics of a basic 60° triangular-wing fuselage model and of a modified 60° triangular-wing fuselage model having half-delta and half-diamond tip controls has indicated the following conclusions:

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1. Although the lift effectiveness at low lift coefficients for both the half-delta and half-diamond controls was lower on the modified wing than on the basic wing, the pitching-moment effectiveness, due to a somewhat longer moment arm, was approximately the same for the basic- and modified-wing configurations.

2. On either the basic or modified wing there was little difference in the lift effectiveness at low lift coefficients between the half-delta and half-diamond controls of equal area, whereas the pitching-moment effectiveness was lower for the half-diamond than for the half-delta controls.

3. The decrease in lift and pitching-moment effectiveness with an increase in lift coefficient was less marked for the modified-wing configurations than for the basic-wing configurations and resulted in higher control effectiveness near the stall for the modified-wing configurations.

4. The half-delta control produced slightly higher maximum trim lift coefficients than the half-diamond control of the same area on both the basic- and modified-wing configurations. Higher maximum trim lift coefficients were obtained when a particular control was mounted on the modified wing than when mounted on the basic wing but at the expense of static longitudinal stability.

5. The decrease in the ratio of trim lift-curve slope to wing lift-curve slope, which occurred with an increase in static margin, was greater for a control on the basic wing than on the modified wing such that, at a static margin of $0.08\bar{c}$, the value for the basic wing was about 5 percent lower than for the modified wing. Changes in control shape or size did not appreciably affect the ratio of the lift-curve slopes.

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TABLE I

PERTINENT GEOMETRIC AND AERODYNAMIC CHARACTERISTICS OF THE MODEL CONFIGURATIONS

No.	Configuration (b)	Control S_c/S_W	Control Type	x (in.)	$\bar{c}$ (in.)	$\frac{x_{H.L.}}{\bar{c}}$	S_W (sq in.)	A	Λ_c (deg.)	C_{L_α}	$C_{m_{C_L}}$	$C_{L_{max}}$
[a]1	Basic W + F	0.100	Half-delta	15.80	21.10	0.512	576	2.31	60	0.042	-0.135	1.085
2	Basic W + F	.053	Half-diamond	15.15	21.85	.524	547	1.72	60	.036	-.071	1.110
3	Basic W + F	.100	Half-diamond	15.55	21.10	.524	576	2.31	40.9	.041	-.118	1.040
4	Modified W + F	.085	Half-delta	17.76	20.53	.675	676	2.65	60	.043	-.134	1.105
5	Modified W + F	.044	Half-diamond	17.32	21.02	.678	647	2.06	60	.039	-.094	1.090
6	Modified W + F	.085	Half-diamond	17.63	20.53	.680	676	2.65	40.9	.042	-.115	1.065

[a] Data obtained from reference 10.

[b] W and F mean wing and fuselage, respectively.

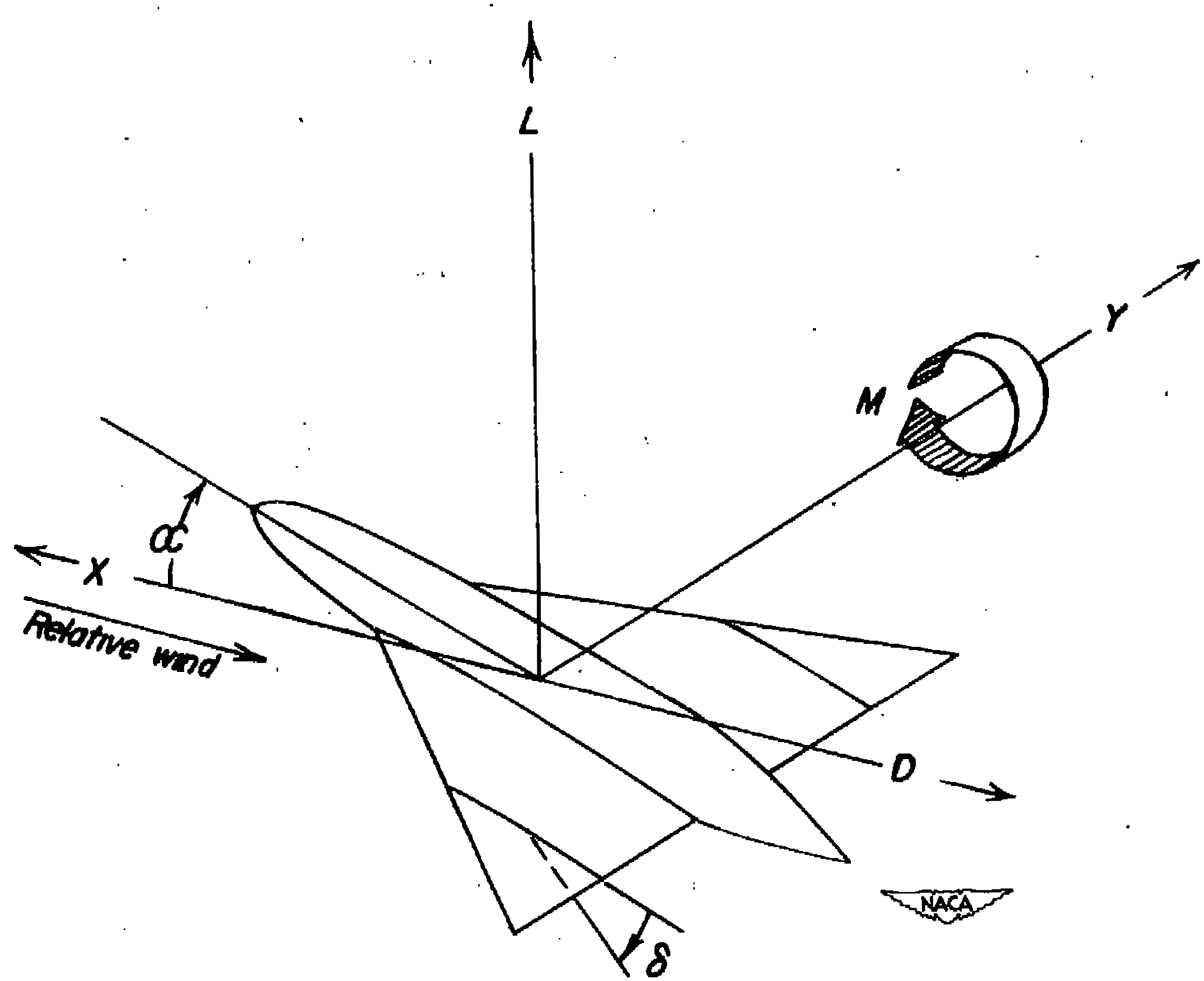

Figure 1.- Stability system of axes. Arrows indicate positive direction of forces, moments, and angular displacements.

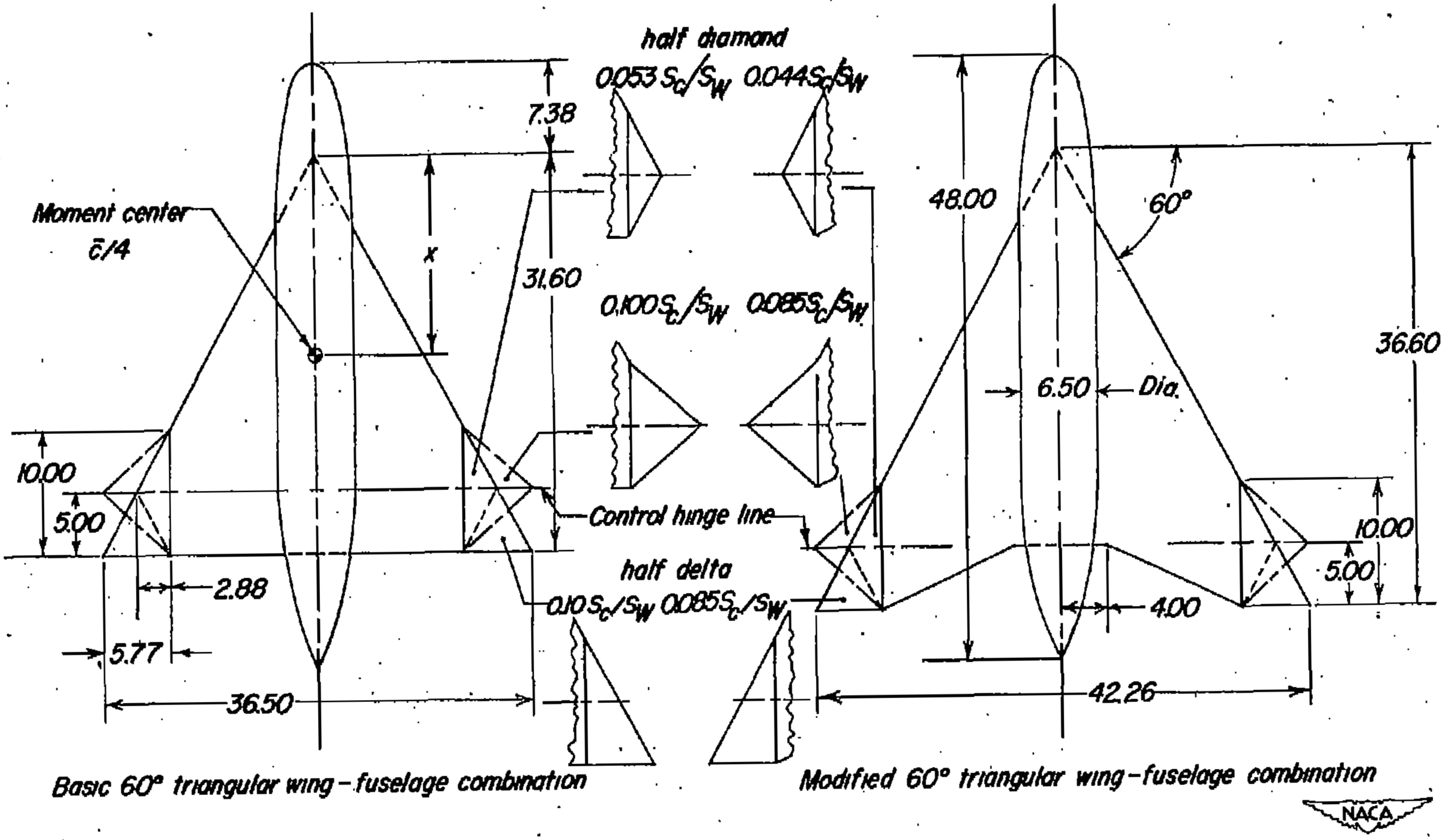

Figure 2.- Sketch of the model used in the investigation. All dimensions are in inches.

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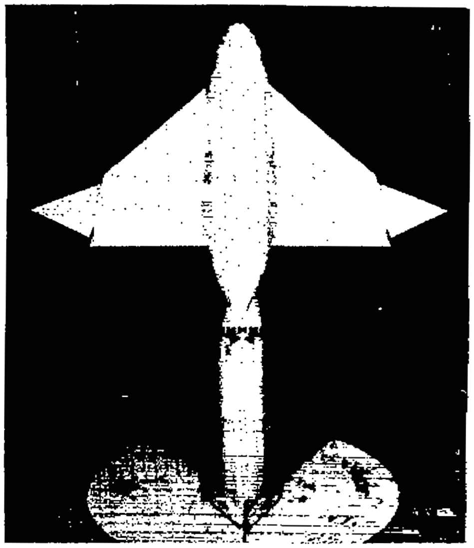

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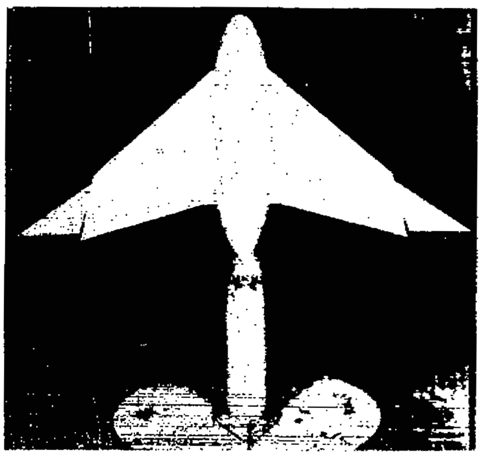
(a) Basic 60° triangular wing-fuselage configuration with $0.100S_c/S_W$ half-diamond controls.



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(b) Modified 60° triangular wing-fuselage configuration with $0.085S_c/S_W$ half-delta controls.

Figure 3.- Photographs of the basic and modified wing configurations as mounted in the Langley stability tunnel.

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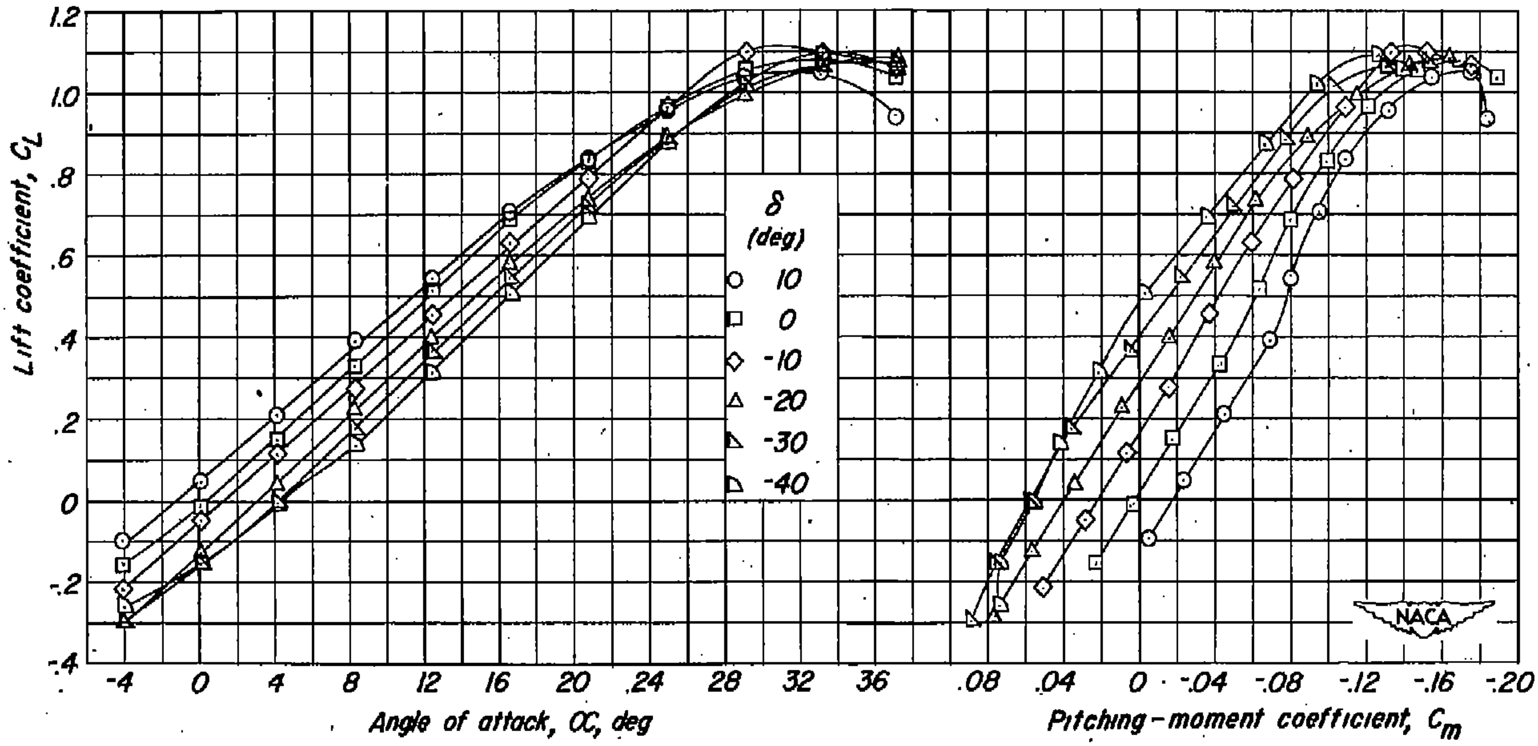

Figure 4.- Longitudinal stability and control characteristics of a 60° triangular wing-fuselage combination with 10-percent half-delta tip controls. Data obtained from reference 10.

[redacted]

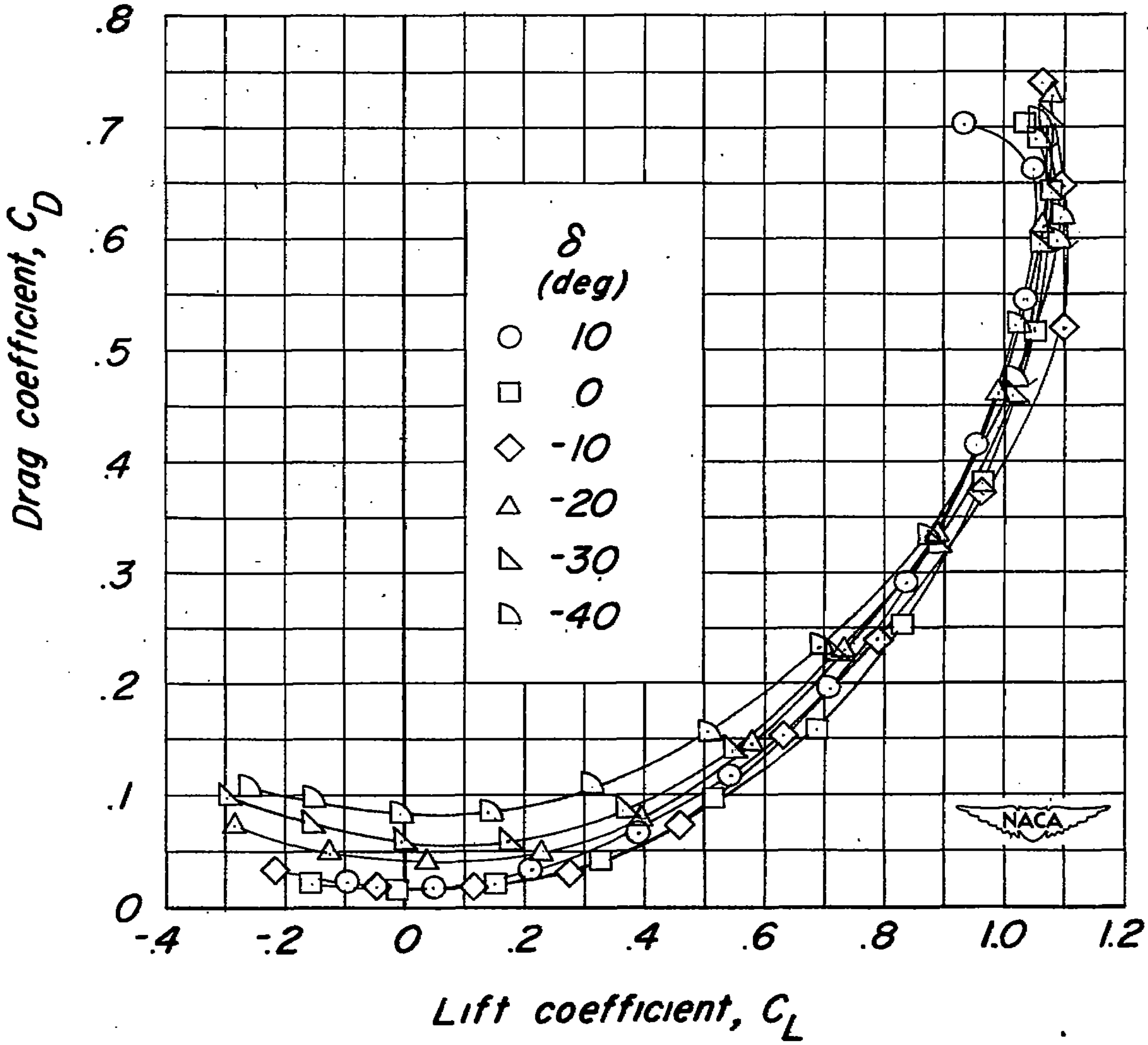

Figure 4.- Concluded.

[redacted]

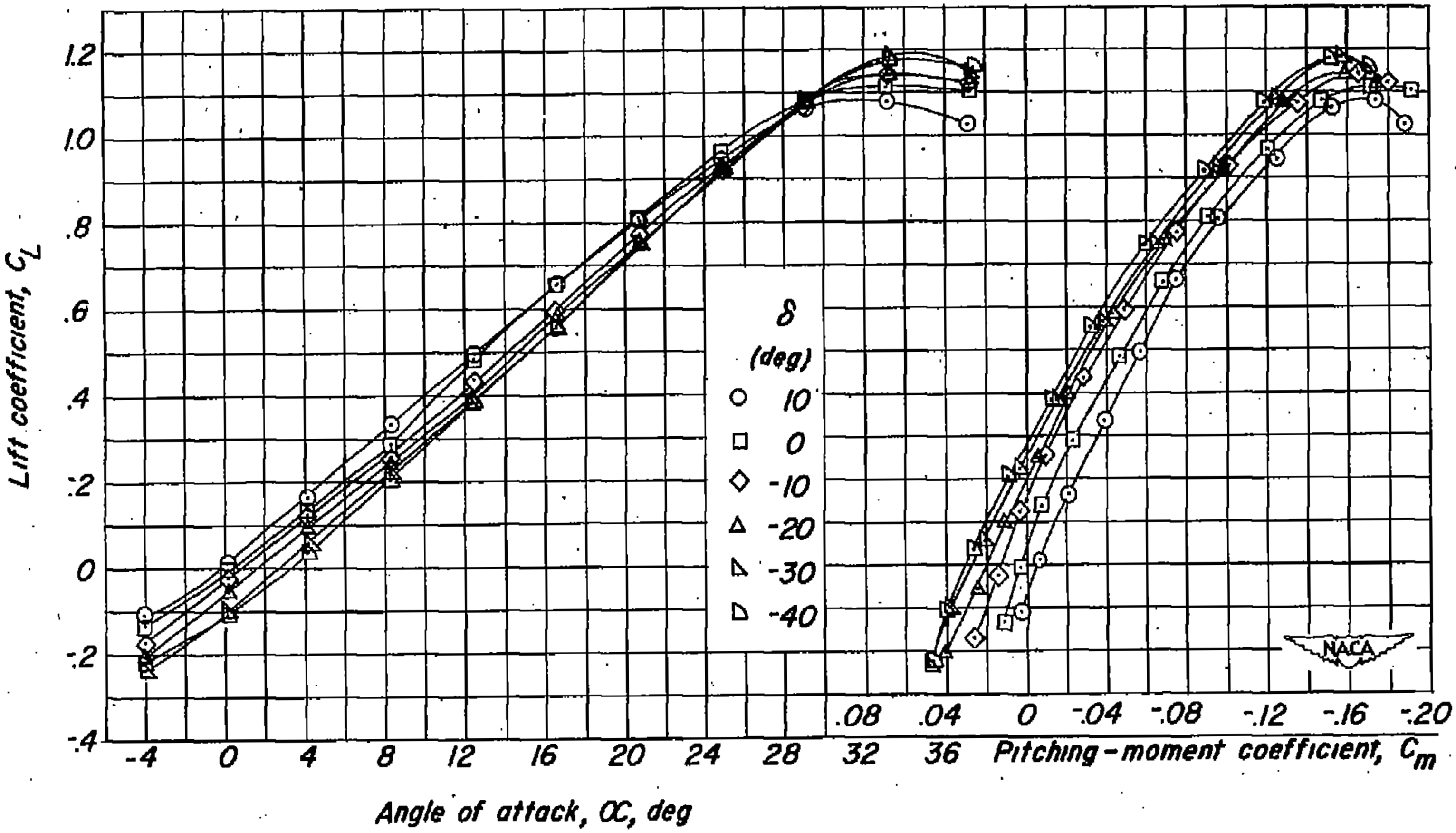

Figure 5.- Longitudinal stability and control characteristics of a 60° triangular wing-fuselage combination with 5.3-percent half-diamond-tip controls.

[redacted]

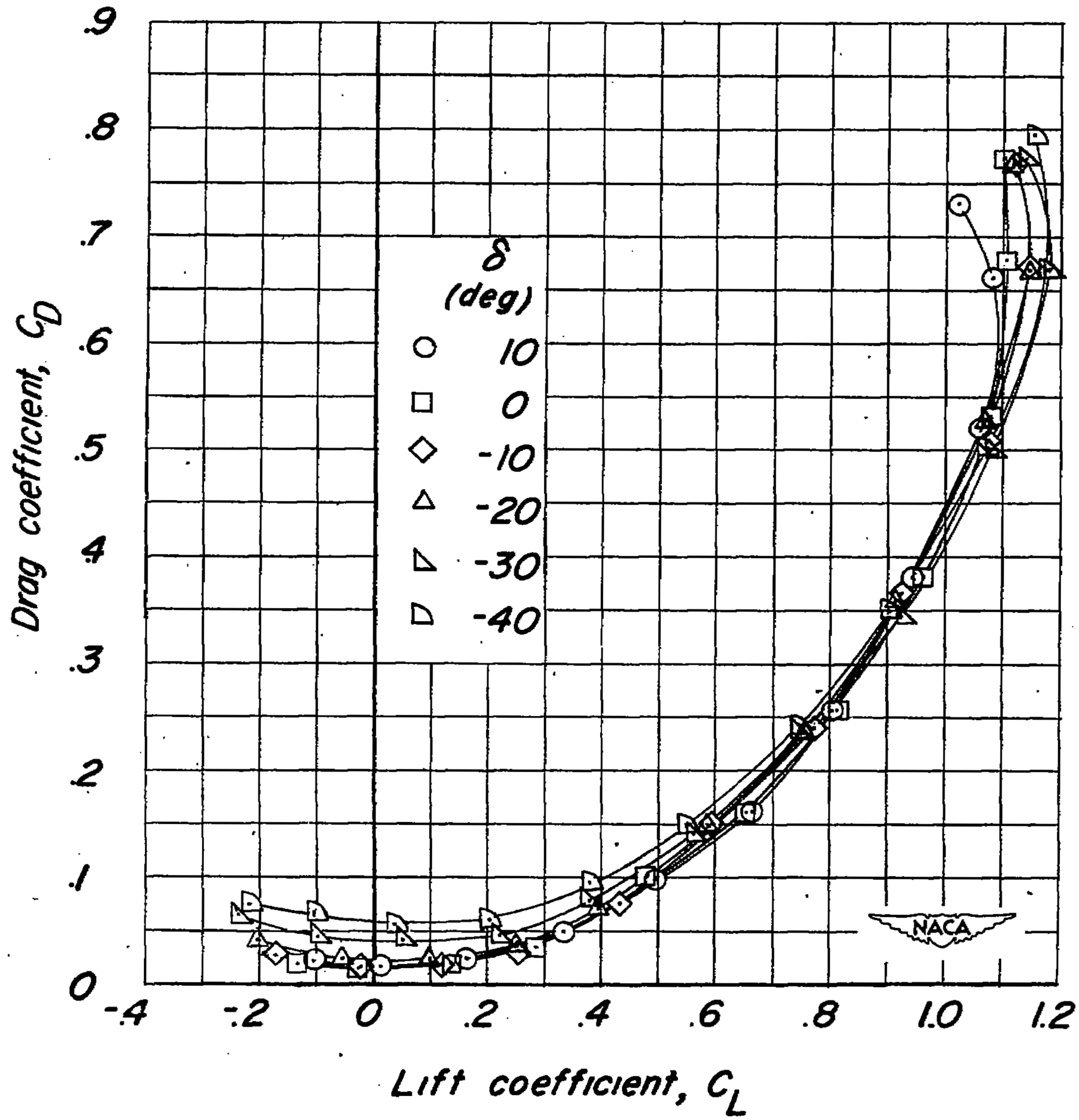

Figure 5.- Concluded.

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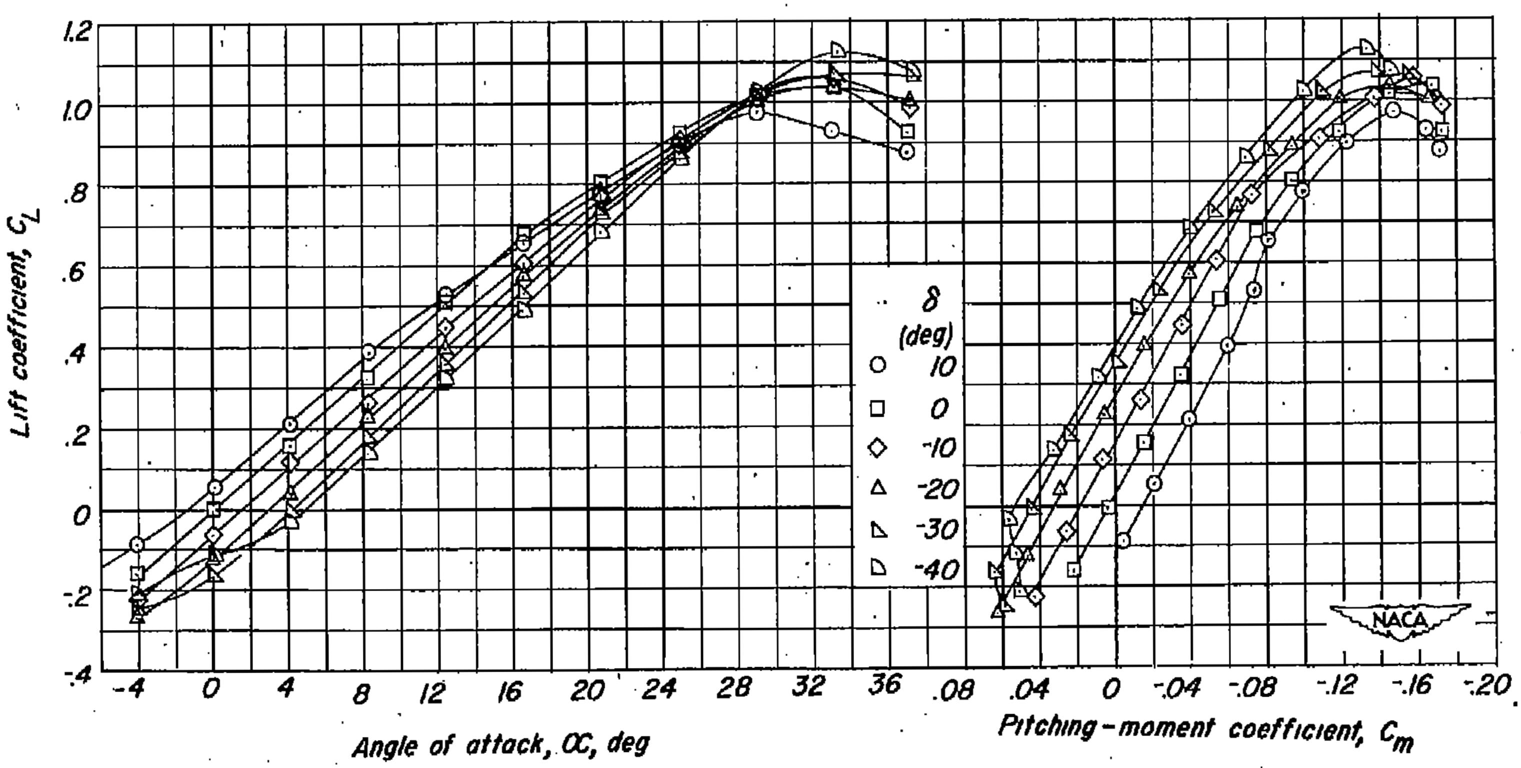


Figure 6.- Longitudinal stability and control characteristics of a 60° triangular wing-fuselage combination with 10-percent half-diamond-tip controls.

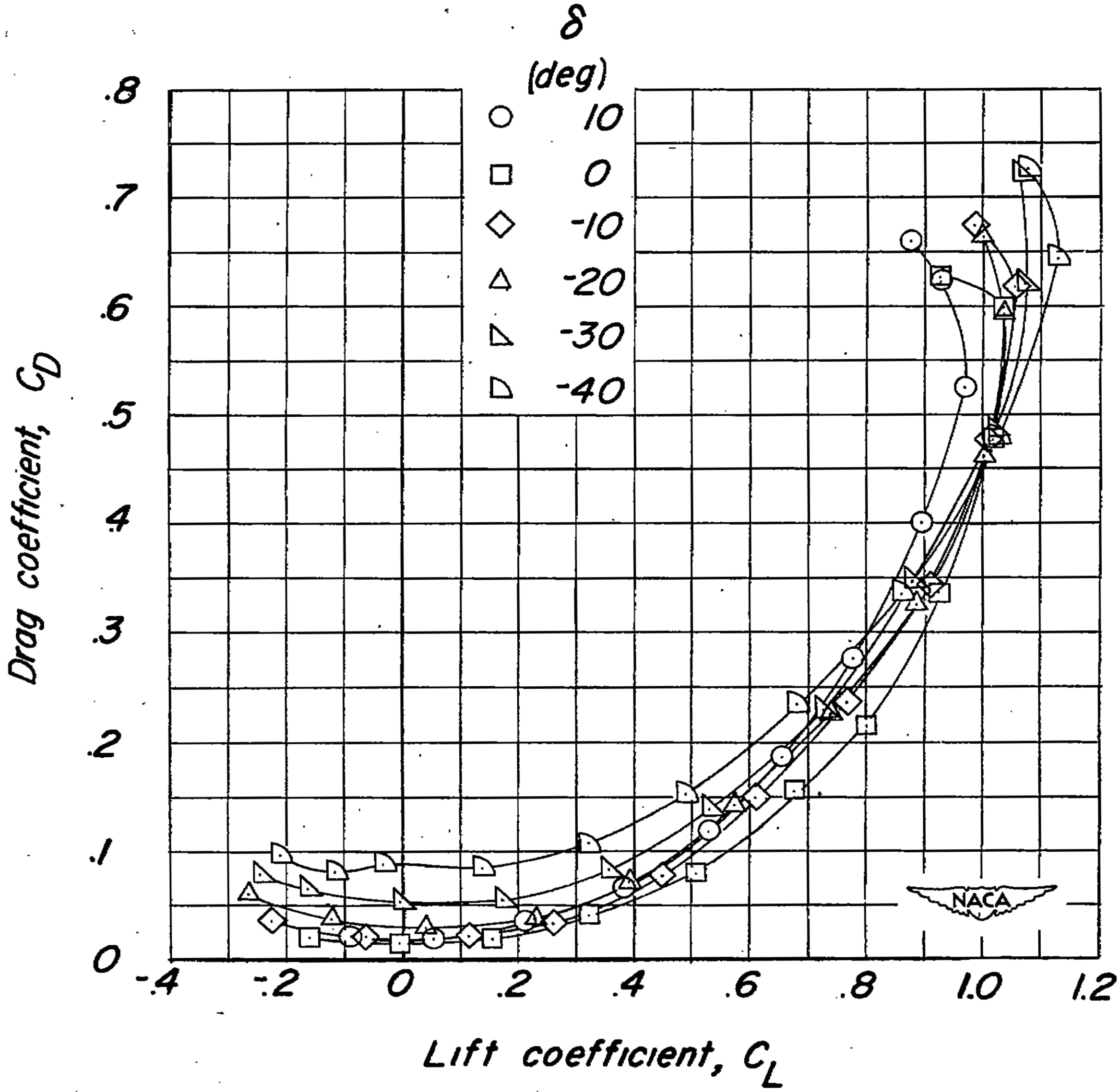


Figure 6.- Concluded.

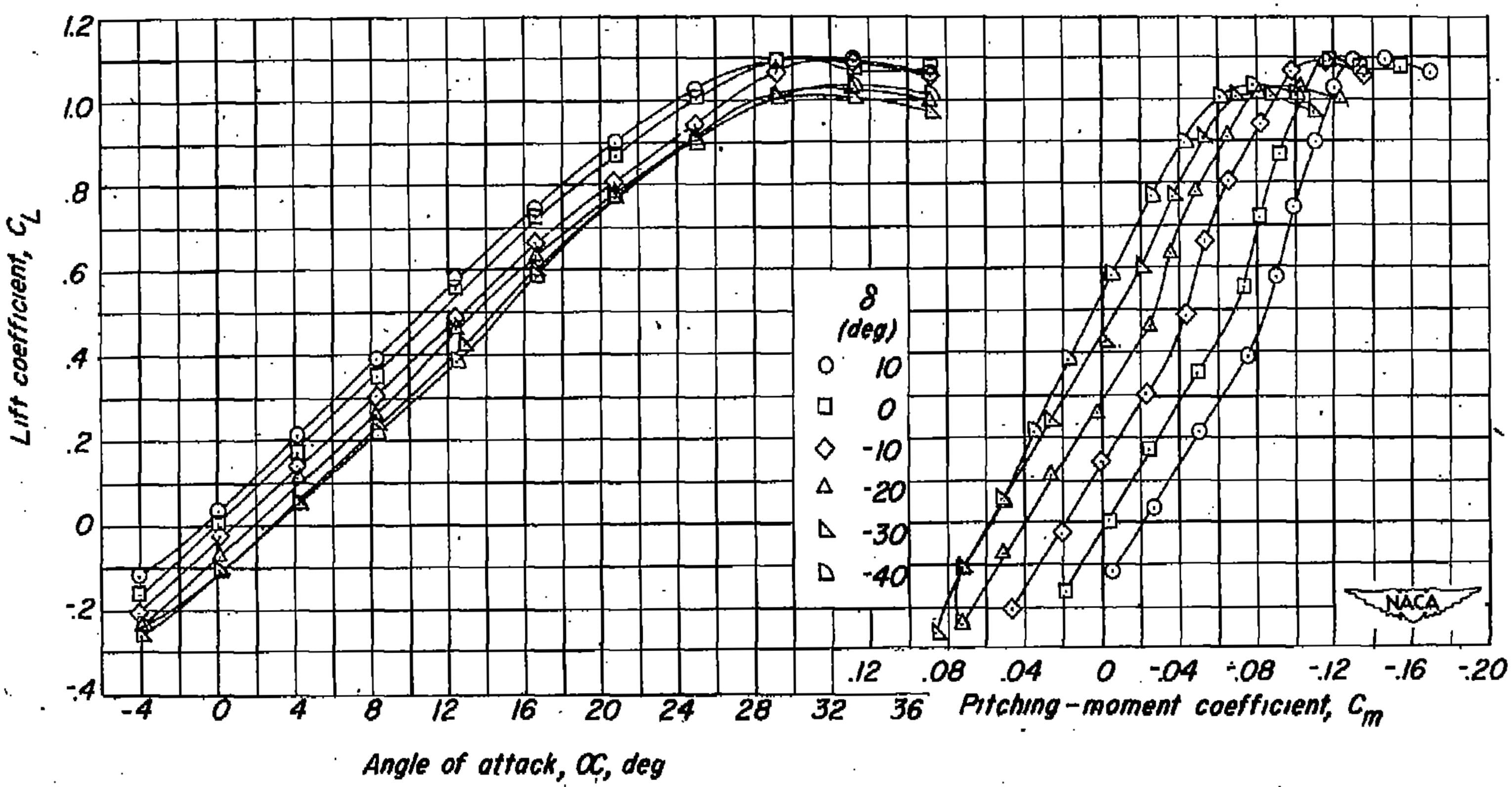


Figure 7.- Longitudinal stability and control characteristics of a 60° modified triangular wing-fuselage combination with 8.5-percent half-delta-tip controls.

[redacted]

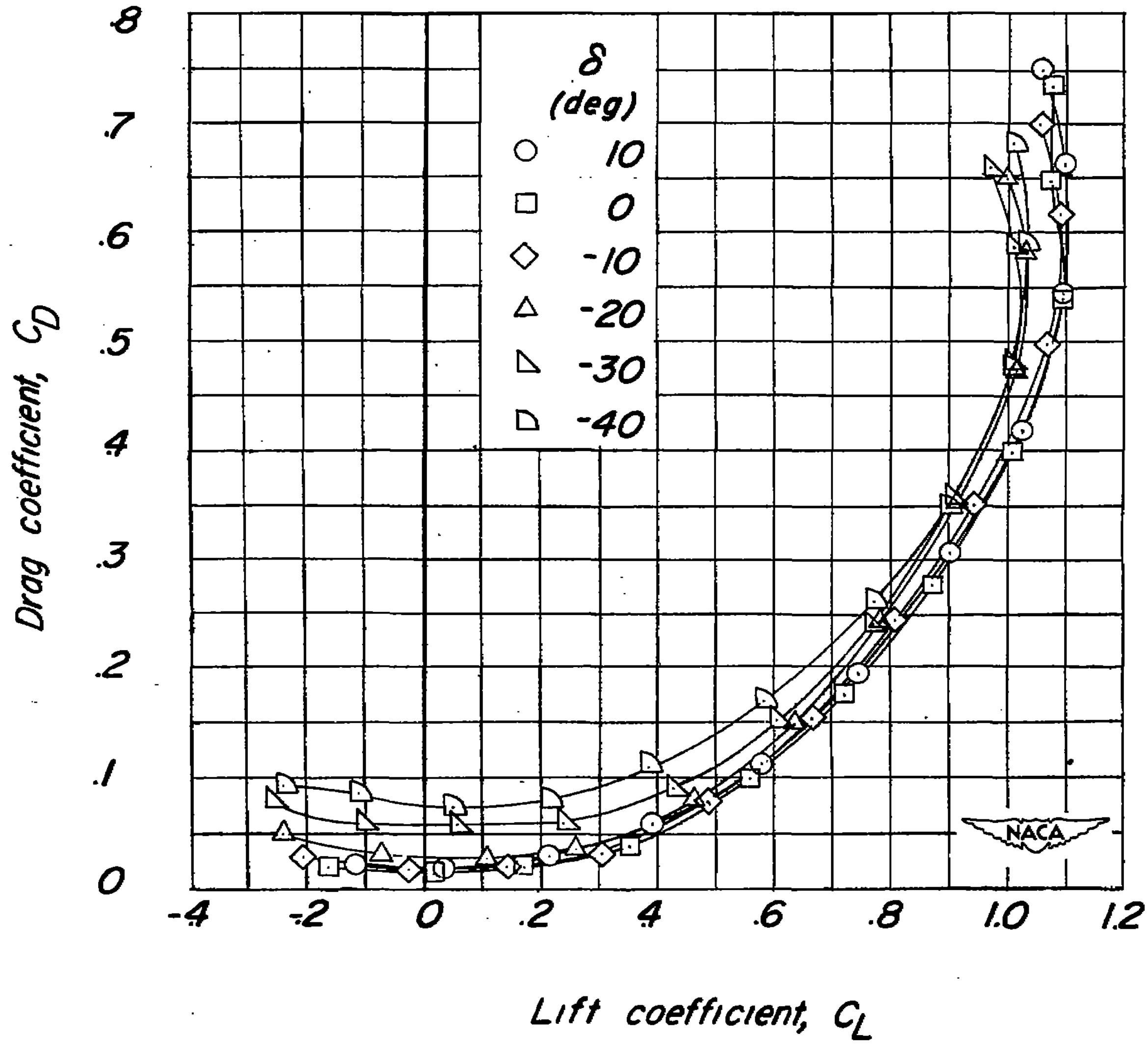


Figure 7.- Concluded.

[redacted]

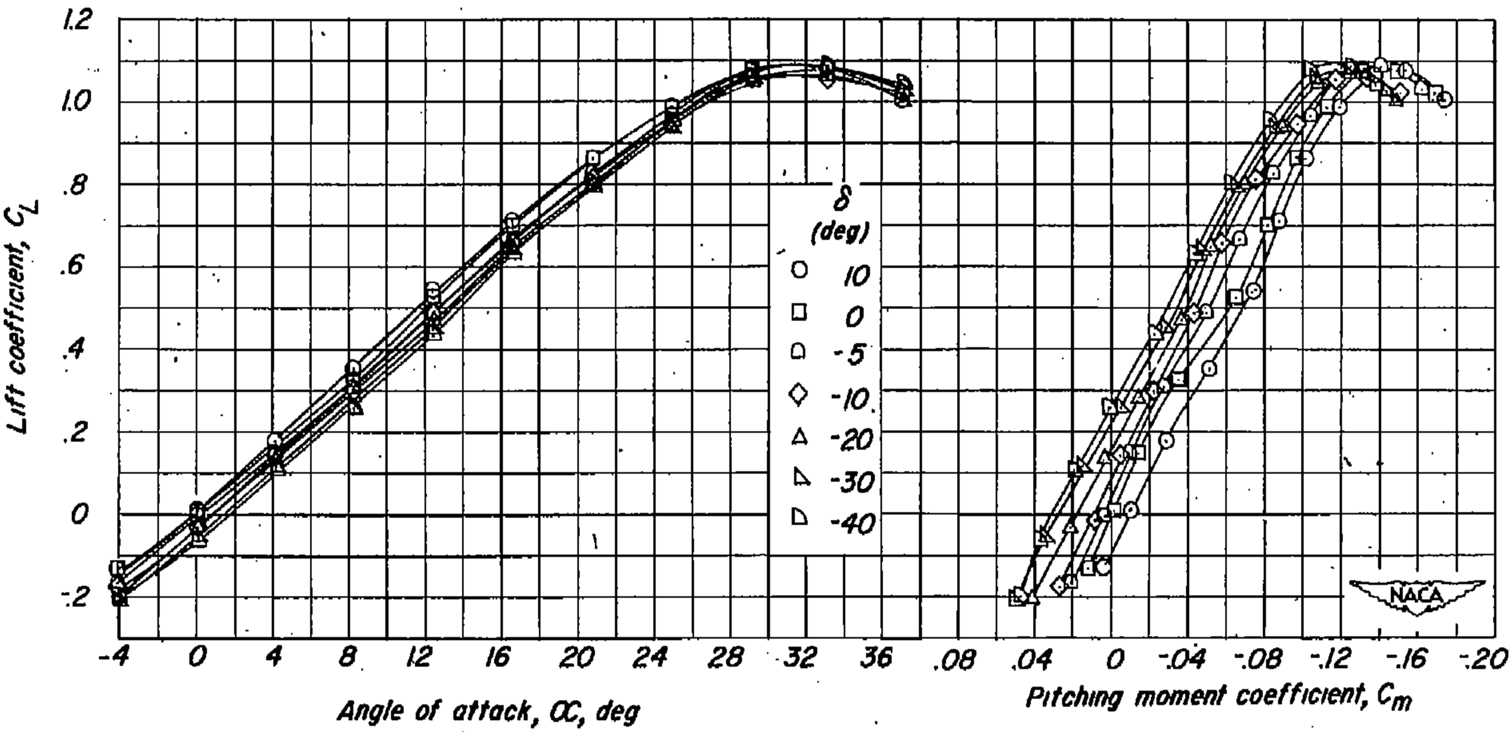


Figure 8.- Longitudinal stability and control characteristics of a 60° modified triangular wing-fuselage combination with 4.4-percent half-diamond-tip controls.

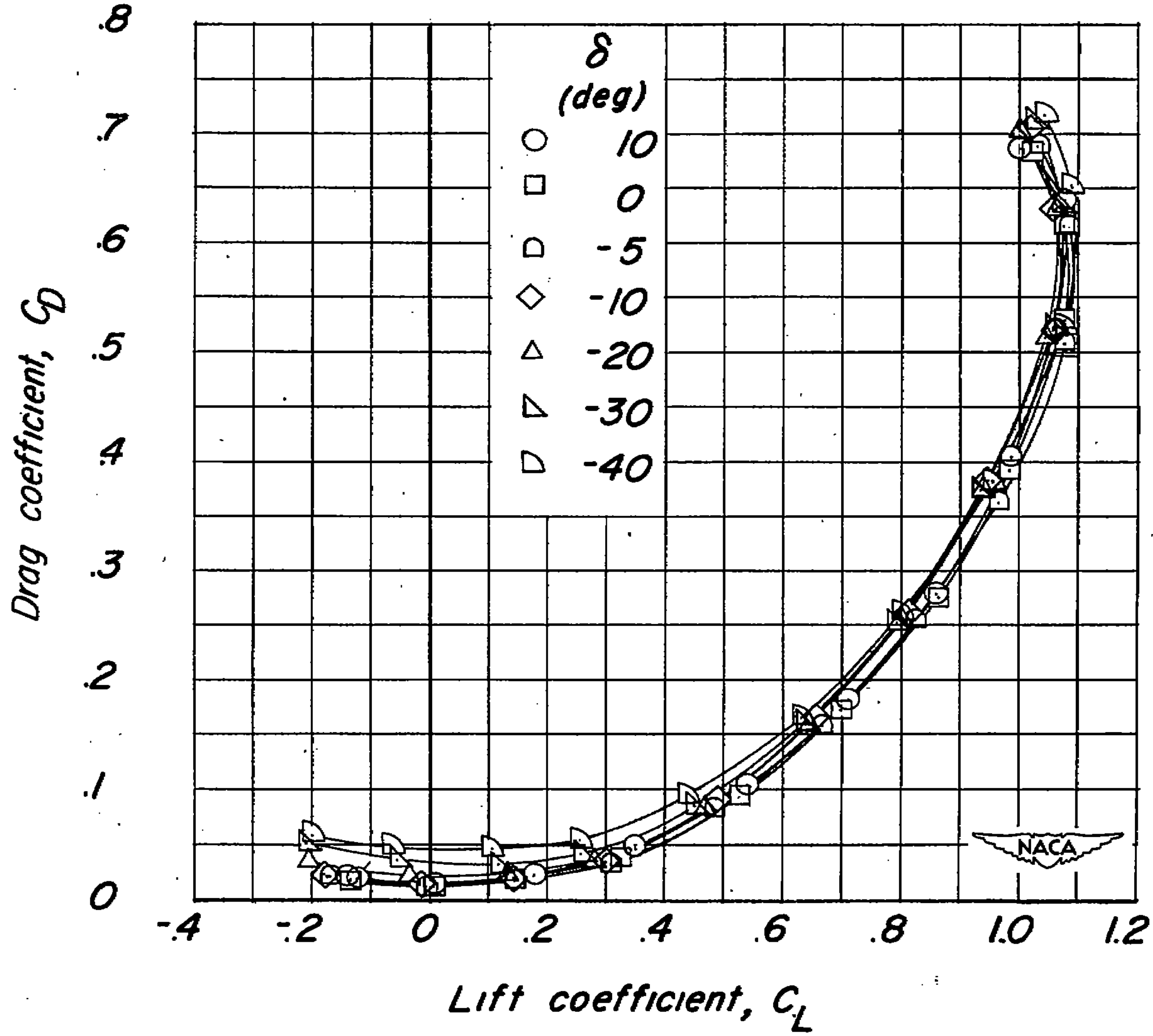


Figure 8.- Concluded.

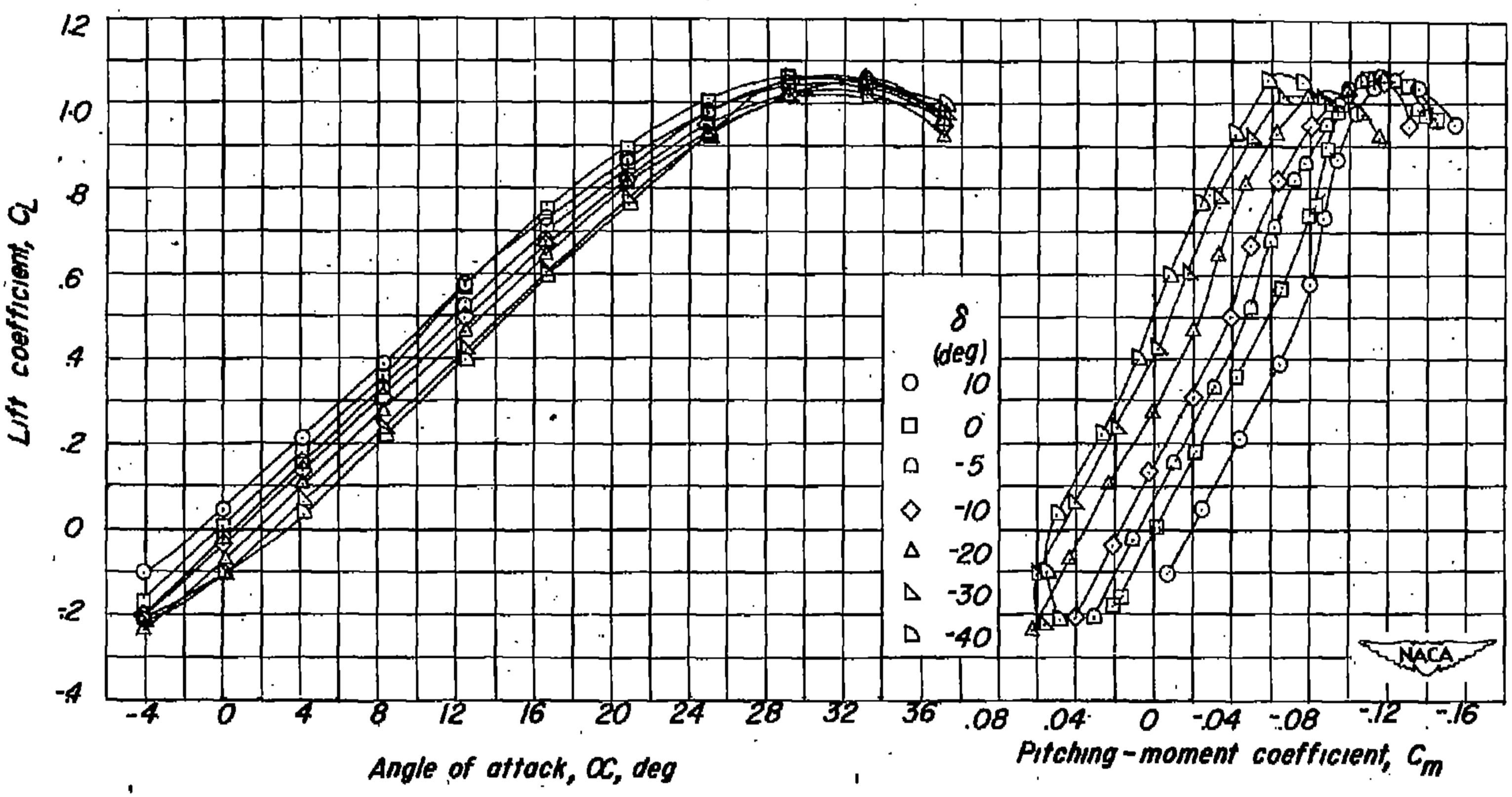


Figure 9.- Longitudinal stability and control characteristics of a 60° modified triangular wing-fuselage combination with 8.5-percent half-diamond-tip controls.

[redacted]

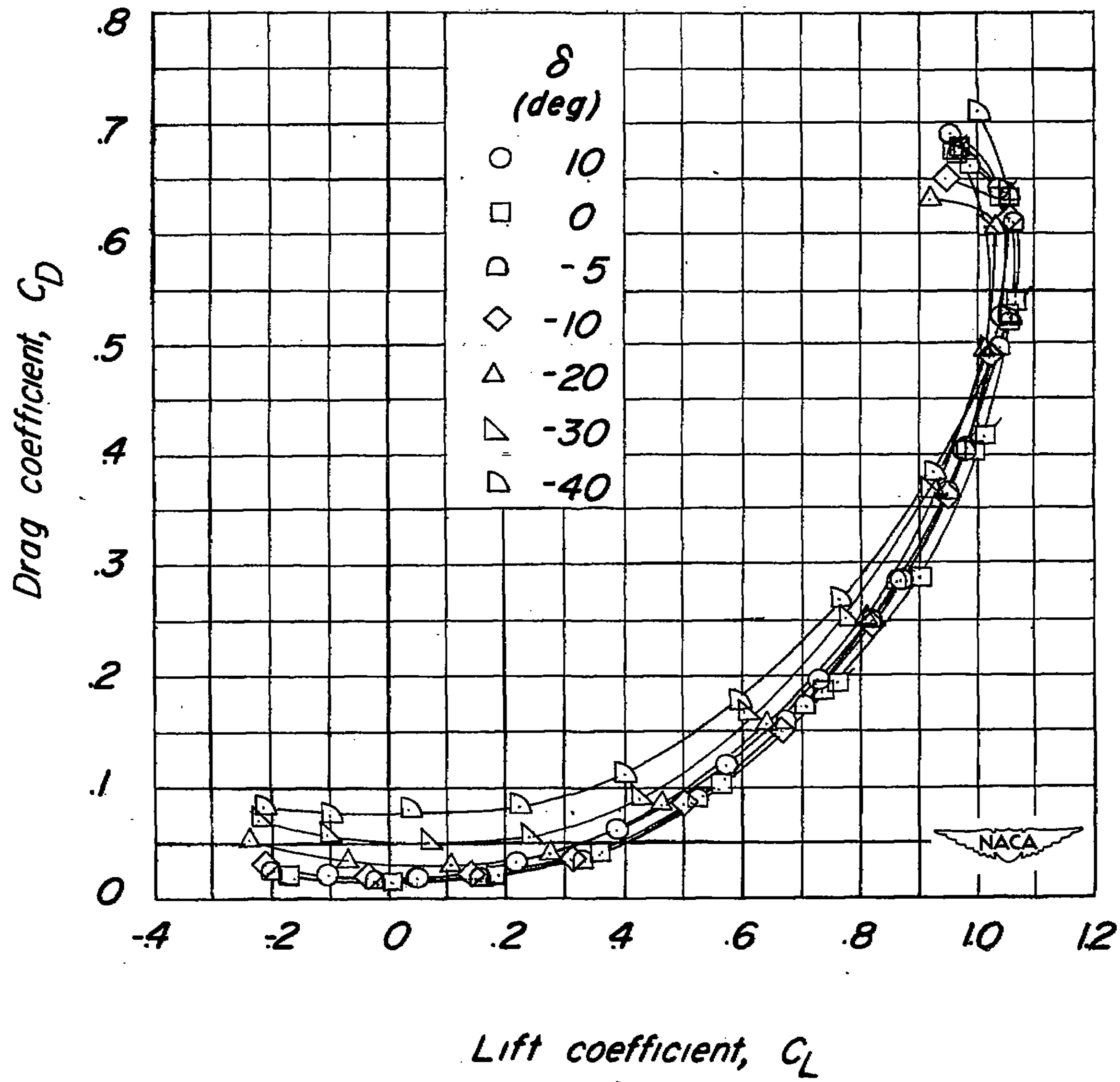
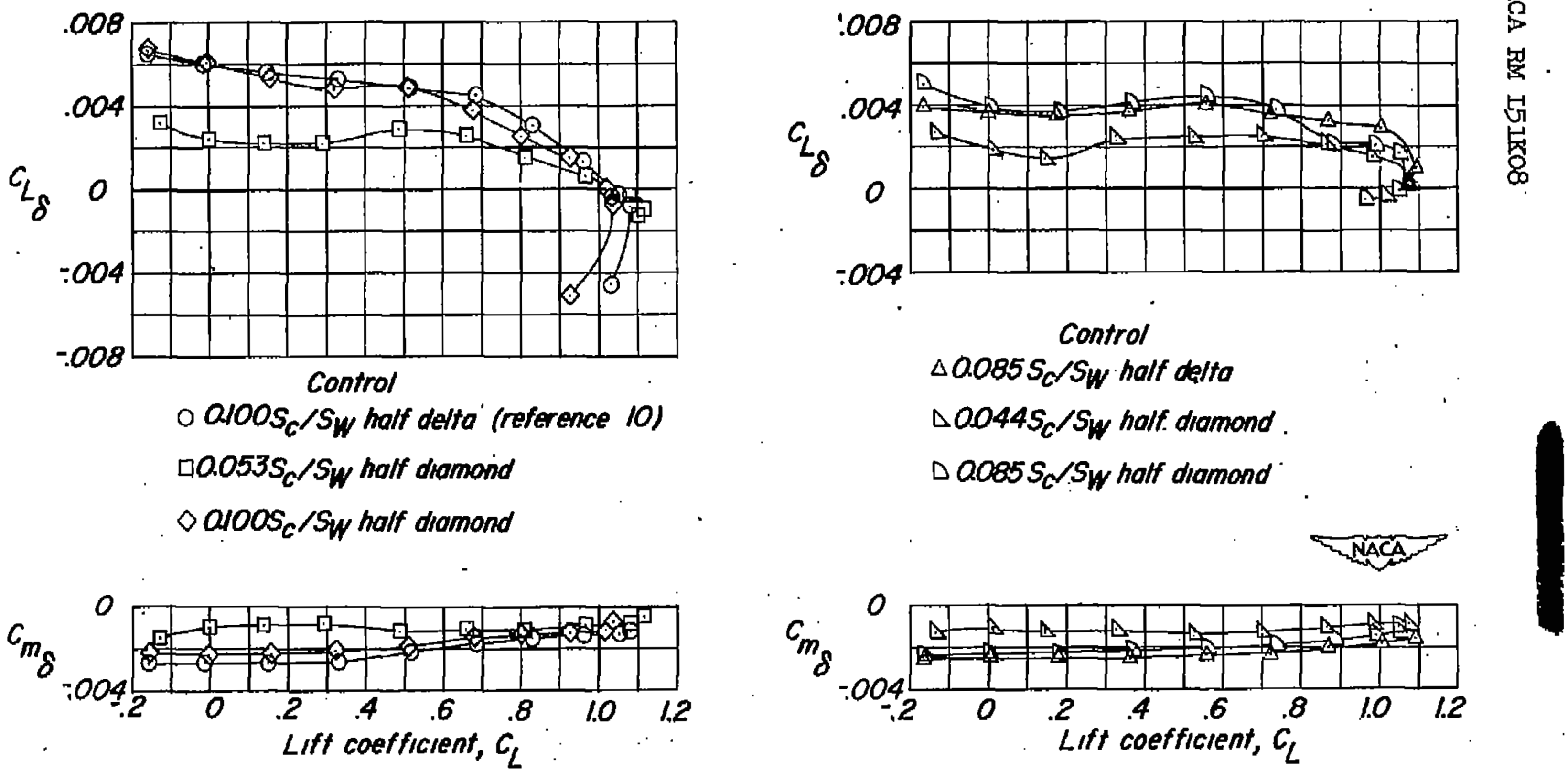


Figure 9.- Concluded.

[redacted]



(a) Effect of size and shape of the tip control on the basic 60° triangular wing-fuselage combination.

(b) Effect of size and shape of the tip control on the modified 60° triangular wing-fuselage combination.

Figure 10.- Variation C_{L_δ} and C_{m_δ} with C_L.

[redacted]

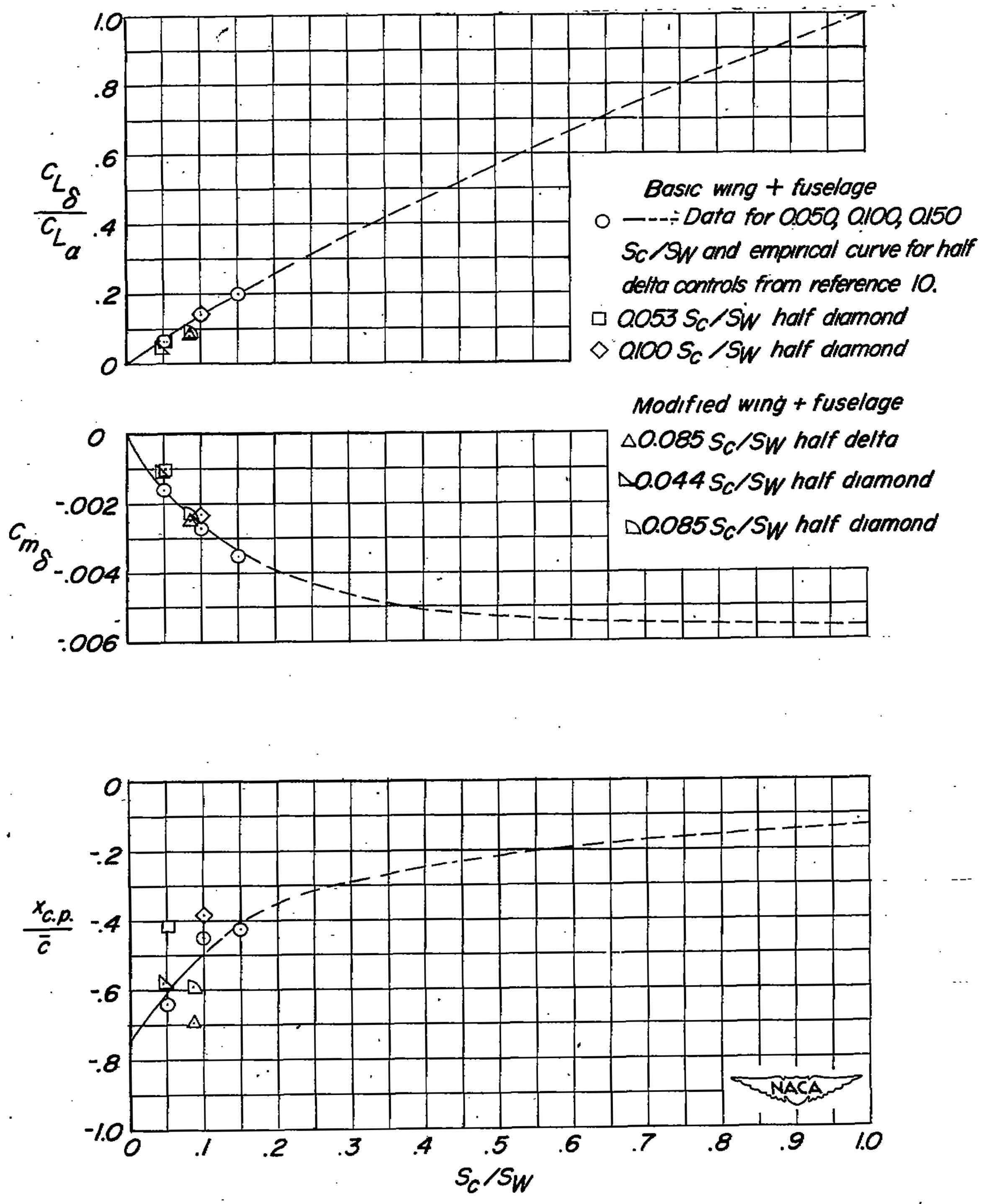


Figure 11.- Effect of control area and plan form on the control effectiveness and center of pressure characteristics. $\alpha = 0^{\circ}$; $\delta = 0^{\circ}$.

[redacted]

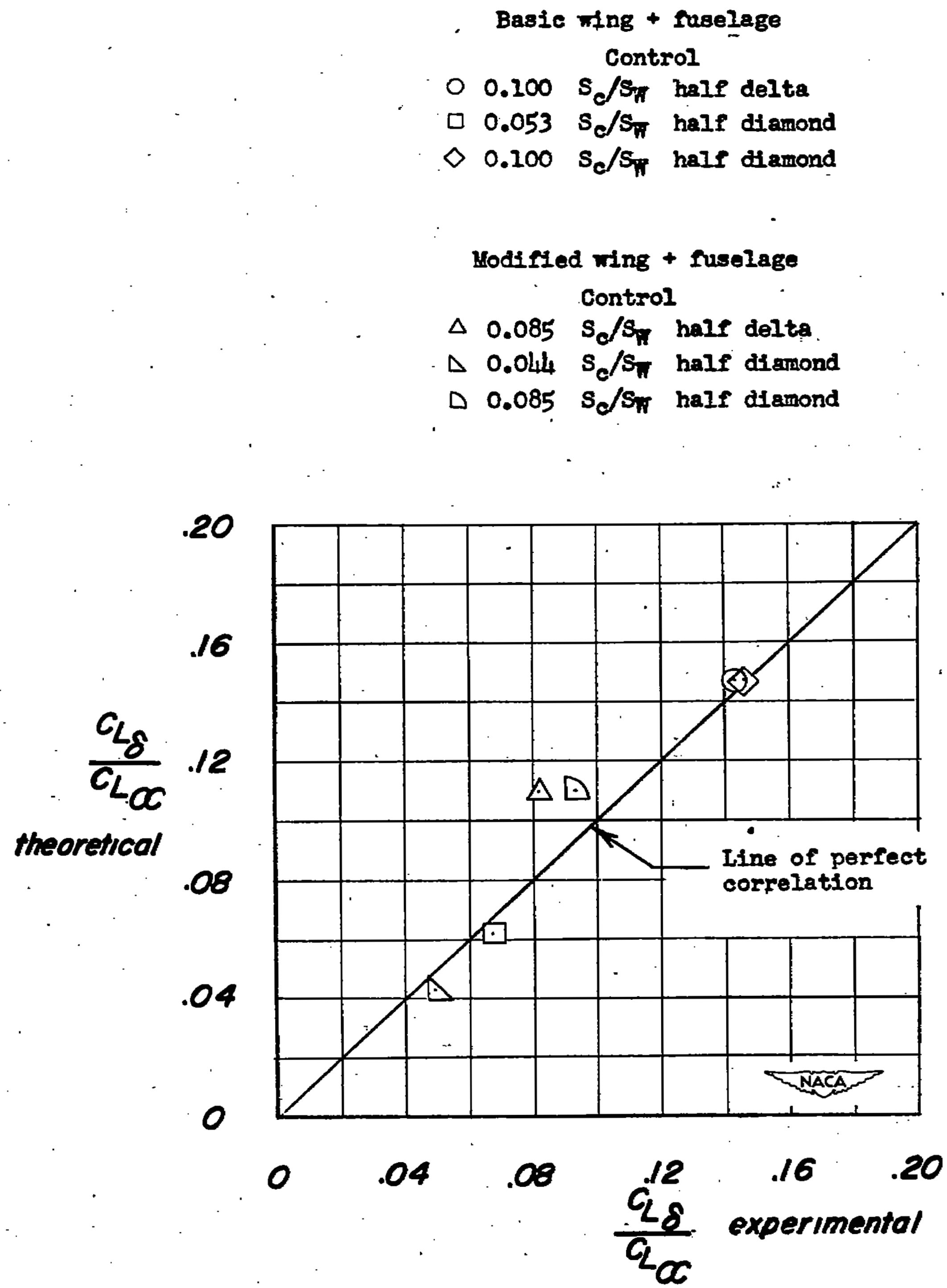
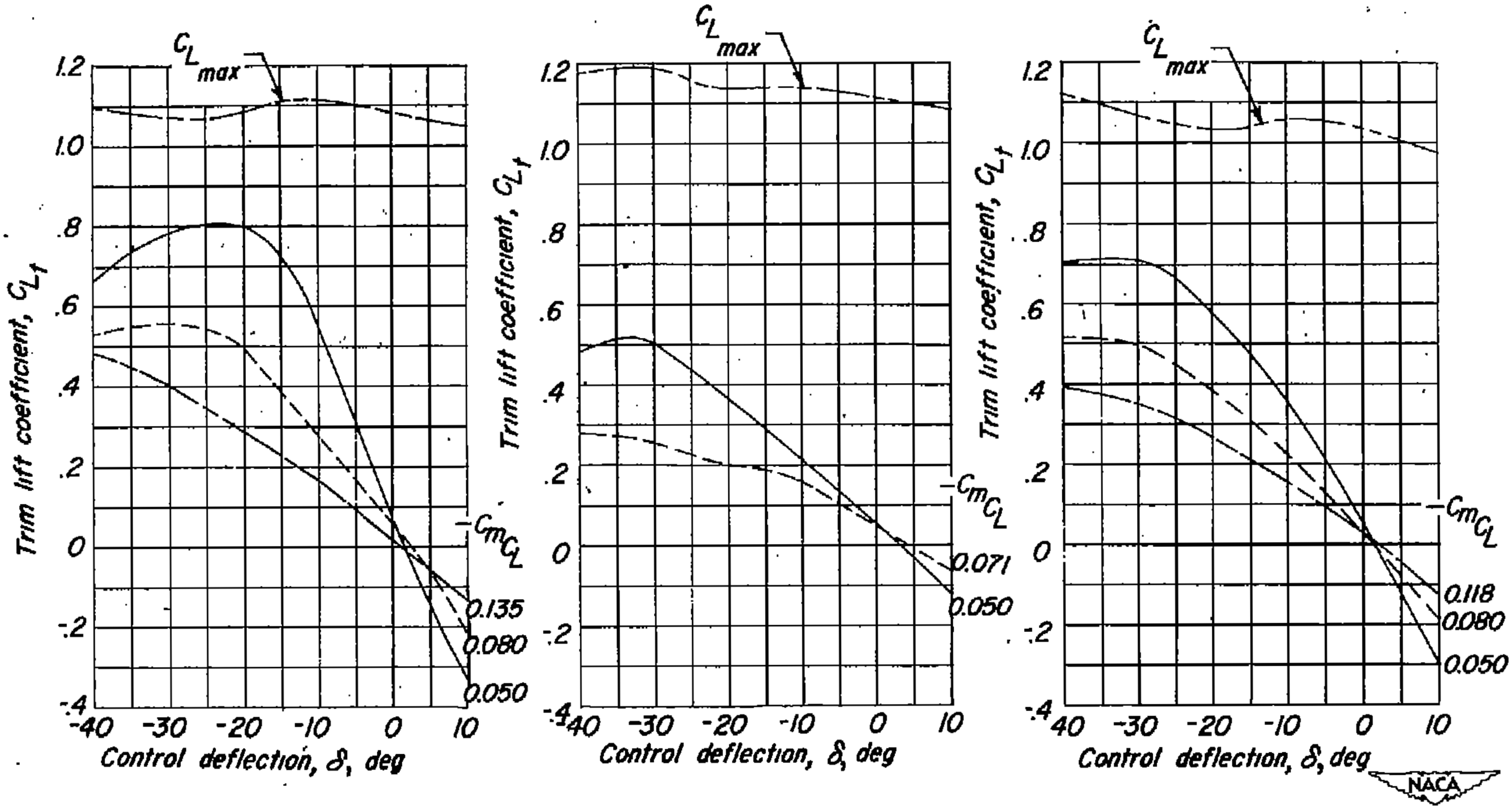


Figure 12.- Correlation of experimental and theoretical values of flap effectiveness.



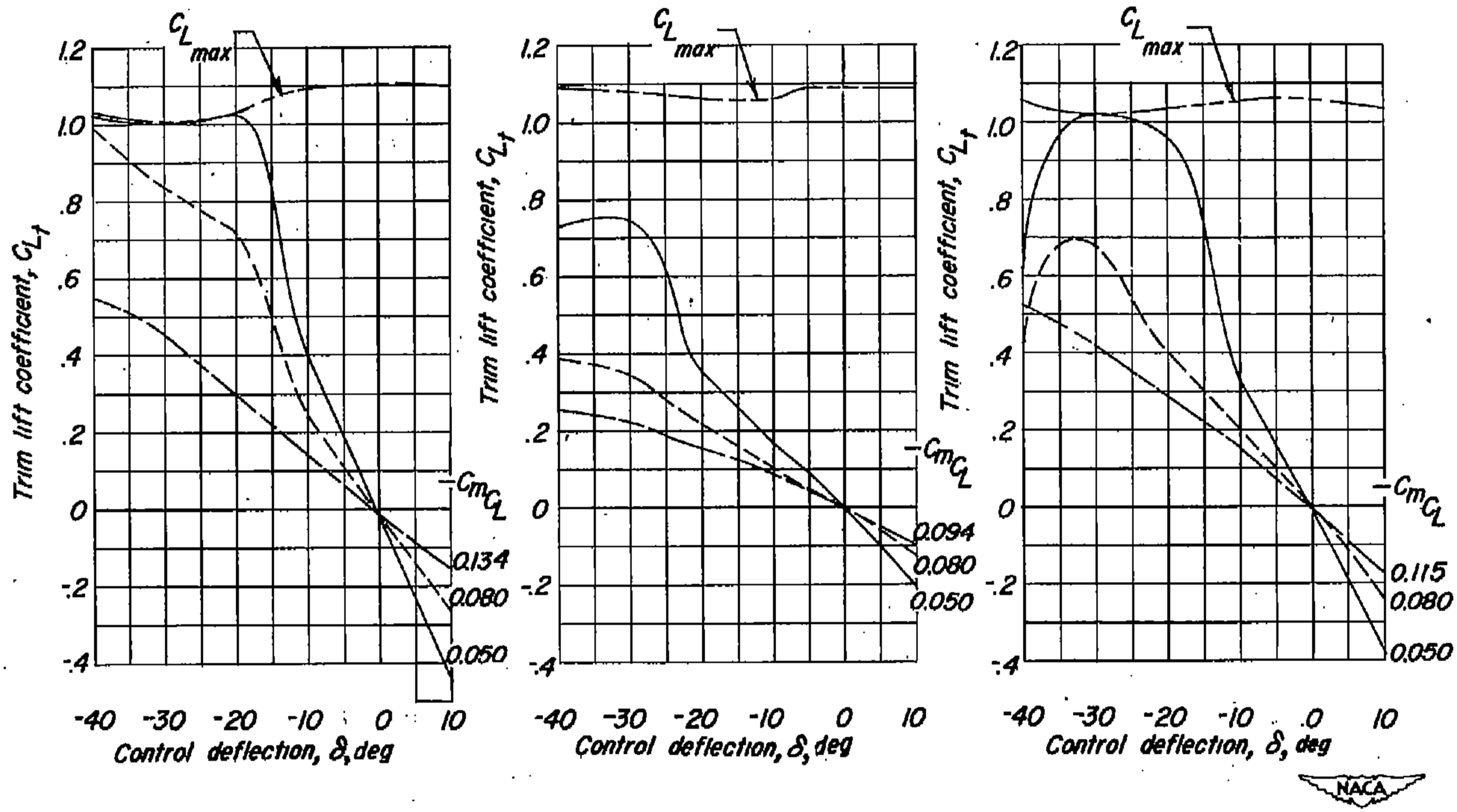
Basic Triangular Wing

(a) Half delta
$\frac{S_c}{S_W} = 0.100$
(reference 10).

(b) Half diamond
$\frac{S_c}{S_W} = 0.053.$

(c) Half diamond
$\frac{S_c}{S_W} = 0.100.$

Figure 13.- Effect of static margin on variation of trim lift coefficient with control deflection for the various tip-control configurations. Wing-fuselage combinations. $C_{m_{C_L}}$ are values at $C_L = 0$.



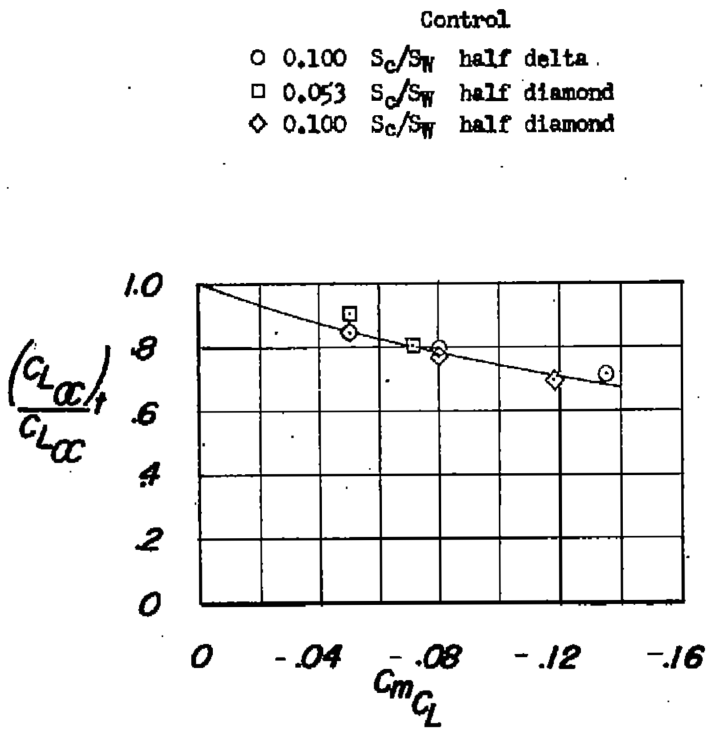
Modified Triangular Wing

(d) Half delta $\frac{S_c}{S_W} = 0.085.$

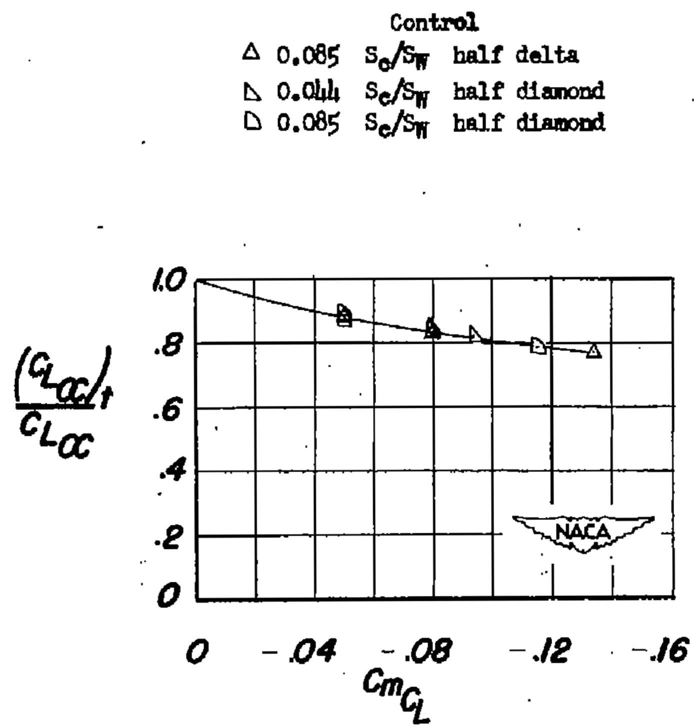
(e) Half diamond $\frac{S_c}{S_W} = 0.044.$

(f) Half diamond $\frac{S_c}{S_W} = 0.085.$

Figure 13.- Concluded.



(a) Basic 60° triangular wing+fuselage



(b) Modified 60° triangular wing + fuselage

Figure 14.- Effect of control area plan form and static margin on the ratio of trim lift-curve slope to wing lift-curve slope. $\alpha = 0^\circ$; $\delta = 0^\circ$.

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SECURITY INFORMATION

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